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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 16 MISSION

ANOMALY REPORT NO. 5

HOLES IN CANOPY OF MAIN PARACHUTE

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS
DECEMBER 1972

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HOLES IN CANOPY OF MAIN PARACHUTE

STATEMENT OF ANOMALY

The canopy of one of the recovered main parachutes had numerous small burn holes similar to the burn holes observed on parachutes from previous missions (see fig. 1). The cause of the holes found on previous missions had been attributed to oxidizer from the reaction control system.

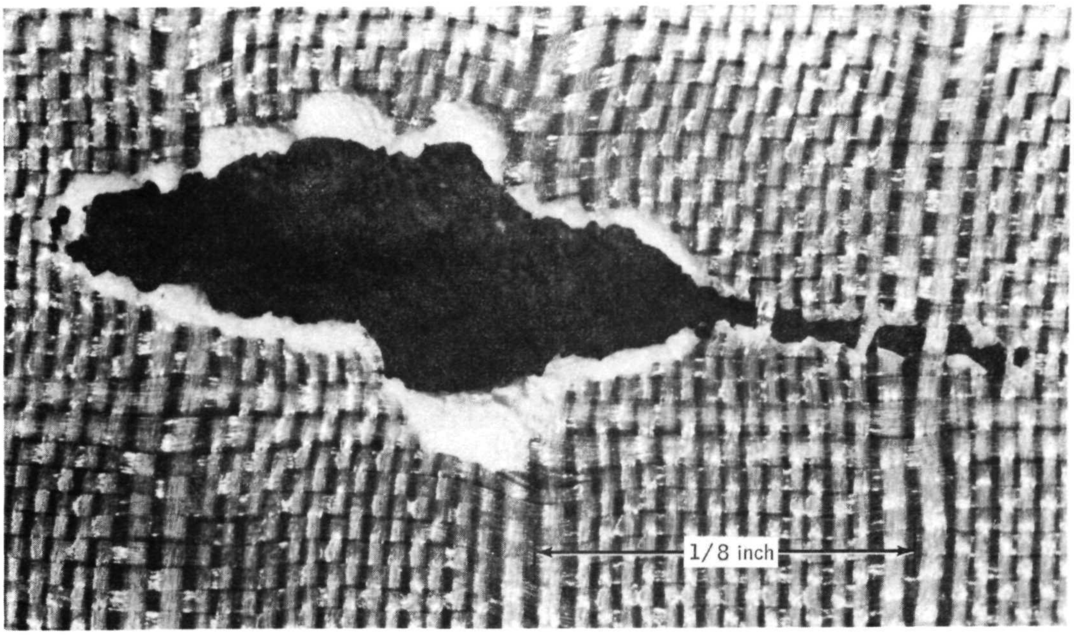
SYSTEM DESCRIPTION

The command module reaction control system consists of two separate and independent systems, each having a pressurization and a propellant system. The propellants are manifolded to rocket engines that provide the thrust required for controlling spacecraft rates and attitudes during entry. Following system usage, shutdown is accomplished by closing the propellant isolation valves. This traps some propellant in the manifolds between the isolation valves and the engines (see fig. 2). The trapped propellants, on past missions, have been released by firing the engines just prior to water landing.

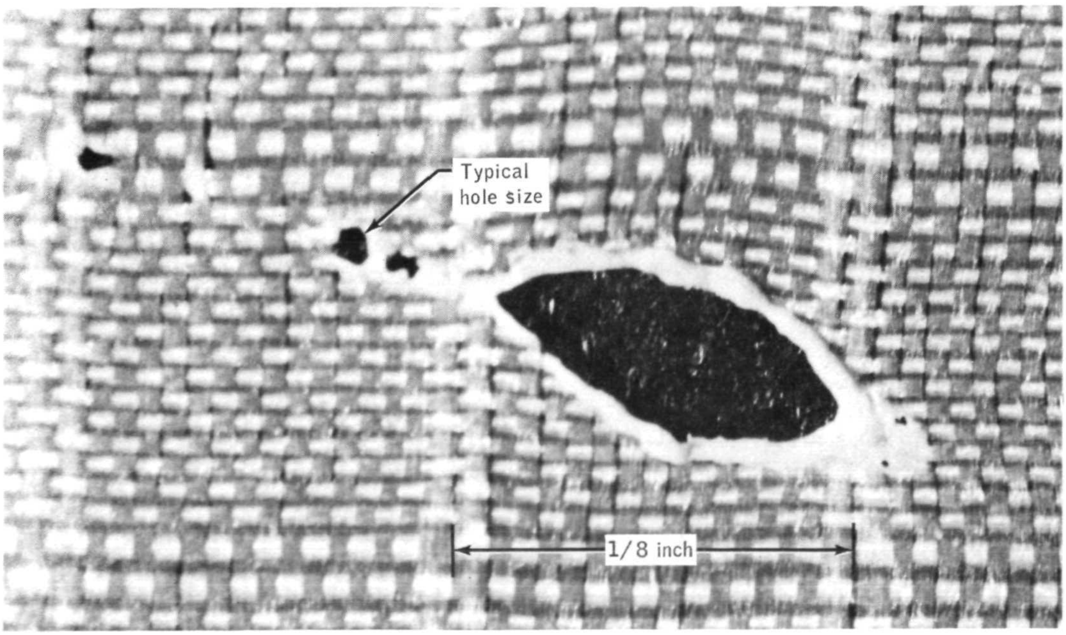
DISCUSSION

The two plus-yaw engines and the two minus-yaw engines were fired at an altitude of about 350 feet for the planned 1-second period to vent the trapped propellants and pressure. Recovery films taken during this period showed that a flame was produced outside the plus-yaw engines for about one-half second. The base of the flame was near the engine nozzles with the upper extremity nearly reaching the parachute risers. A red vapor cloud, considered to be oxidizer, also emanated from the plus yaw engines for about 1 second. Clouds or flames were not observed from the minus-yaw engines, indicating that all the trapped propellants were vented during the plus-yaw engine firings.

The engines were fired because there was concern that increasing pressure, resulting from sea-water immersion of the reaction control system lines between the isolation valves and the thrusters, could reach the burst limits of the weakest component — the thruster assembly. The temperature of the reaction control system lines prior to landing is about 55° F; however, after landing, immersion can raise the temperature of the lines to the water temperature of about 85° F.



(a) Apollo 4 parachute.



(b) Apollo 16 parachute.

Figure 1.- Typical burn holes found in recovered parachutes.

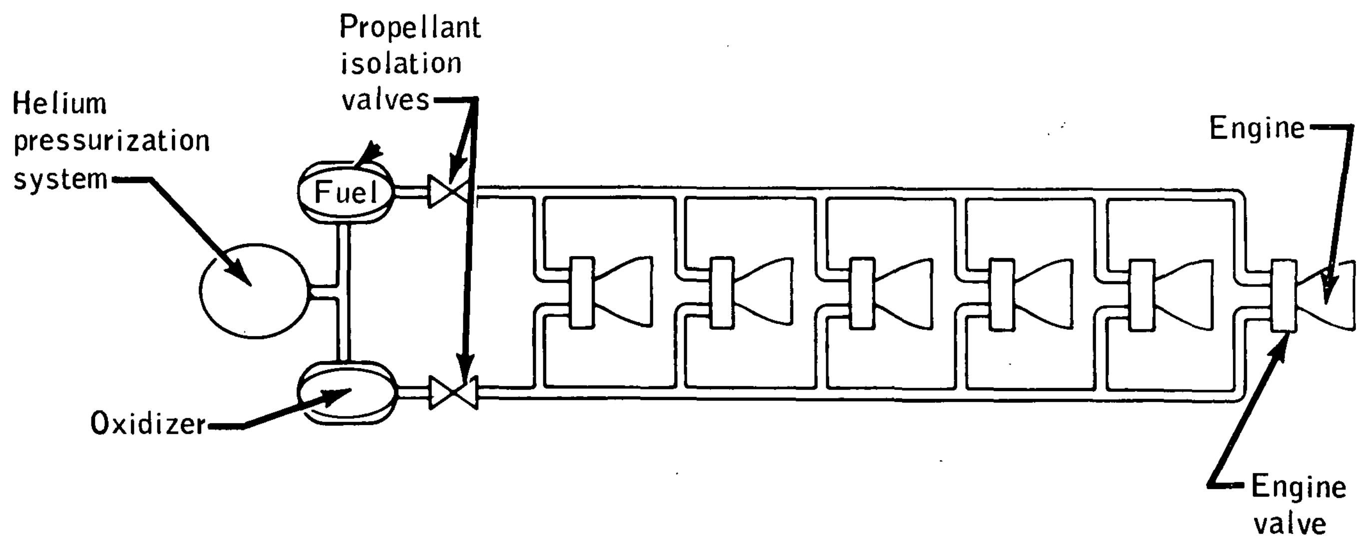


Figure 2.- Command module reaction control system engine manifold schematic.

Tests and analyses were performed to determine the capability of the system to withstand the pressure rise and to establish whether or not the engine firing was necessary to relieve manifold pressure. Results showed that system pressures can exceed 4800 psia, if not relieved. The isolation valves, however, will normally relieve the back pressure through the valve at 650 to 800 psia as shown in figure 3, and if the poppet sticks closed, the pressure will be relieved through the valve seal at 3400 psi. Pressure capabilities of the remaining components are 6200 psia and 5000 psia for the propellant lines and flexible lines of the system and manifold assembly, respectively, and 5000 psia for the engine valves.

CONCLUSIONS

The burn holes in the parachute were the result of oxidizer being expelled when the plus-yaw engines were fired as the spacecraft was in the final phase of descent. The engine firing is not required to relieve the manifold pressure.

CORRECTIVE ACTION

For Apollo 17 and subsequent missions in which the Apollo spacecraft is used, the command module will be landed with the reaction control system pressurized and the propellant isolation valves closed.

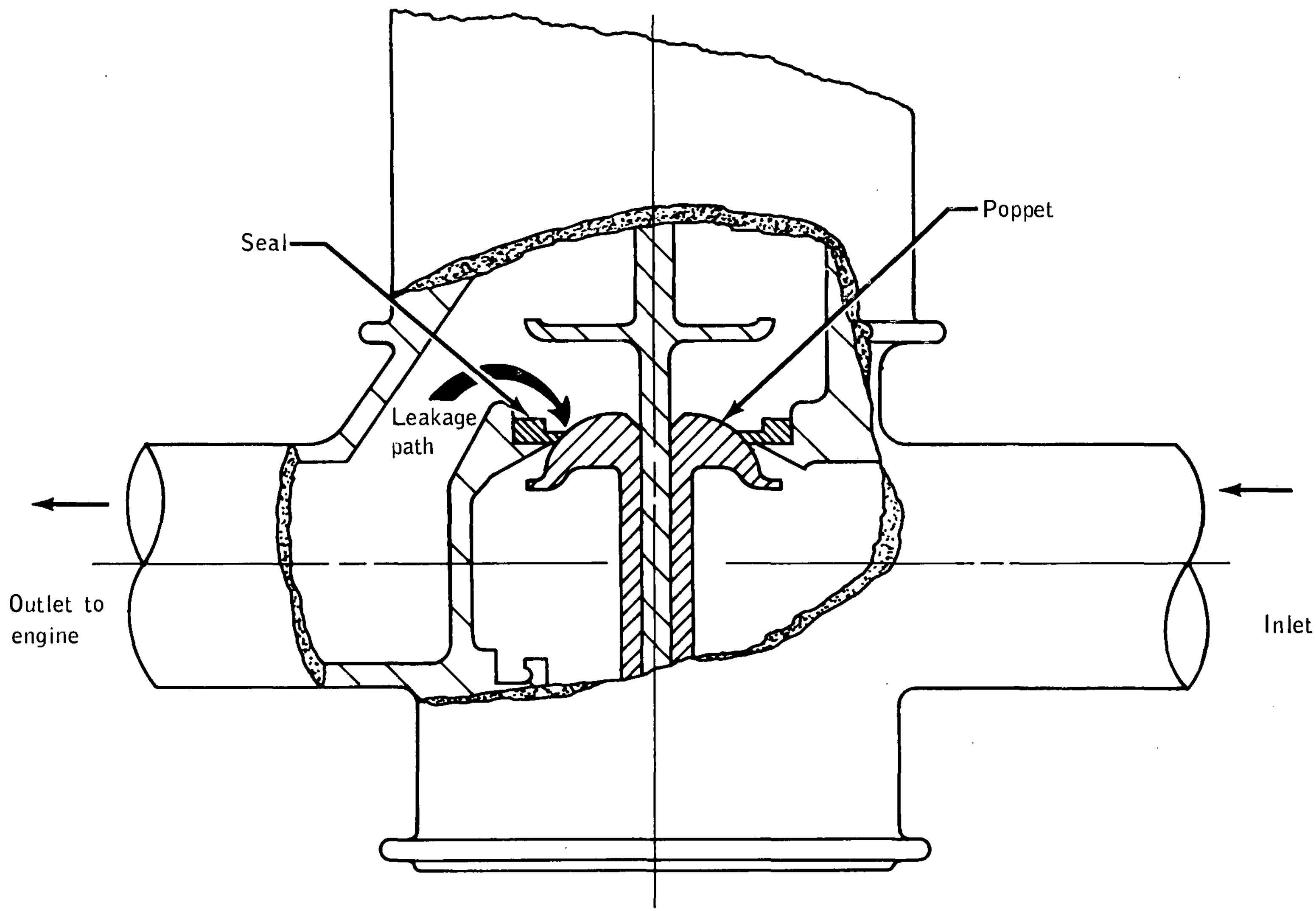


Figure 3.- Reaction control system manifold valve.